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# GEOPHYSICAL INVESTIGATION FOR GROUND WATER DEVELOPMENT WITHIN THE PREMISES OF ABUAD INTERNATIONAL SCHOOL, AFE BABALOLA UNIVERSITY, ADO-EKITI, EKITI STATE, NIGERIA

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*A geophysical investigation is necessary for groundwater development in Basement complex areas like ABUAD International School of Afe Babalola University due to varied geological properties of the underlying aquifers present. A Vertical Electrical Sounding (VES) electrical resistivity method was adopted within the study area. Vertical Eletrical sounding using Schlumberger array was conducted at (6) VES stations. The study was carried out to determine the sub surface layer resistivity and thickness in order to use same to categorize the groundwater potential of the study area. The field data obtained were analysed using the winResist computer software which gives an automatic interpretation and plotting of the apparent resistivity. Generally, results obtained revealed four subsurface/geoelectric layers which are topsoil, hardpan/lateritic clay, weathered basement and fractured basement. The depth to the basement (overburden thickness) beneath the sounding stations is assumed to include the topsoil, lateritic clay and weathered/fractured rock. The values range from 1.0m to 17.9m with an average thickness value of 12.0m. It can be concluded that the low resistivity and significantly thick weathered rock/clay and the fractured basement constitute the aquifer in this area. Results from this study have revealed that The location around the VES 3, 5, & 6 points are the most promising region for borehole development and the estimated depth of the borehole is 60-65m deep and the overburden btw 9.9 – 12.9m.*

# INTRODUCTION

Afe Babalola University, Ado-Ekiti (ABUAD) is a fast growing private University in Nigeria. The continuous increase in progressive infrastructural development within the University resulting in the establishment of ABUAD International School, Ado-Ekiti necessitated the development of a sustainable water supply network for domestic uses for the newly established school.

Groundwater exploitation has continued to remain an important issue, although there are other sources of water; streams, rivers ponds, etc., none is as hygienic as groundwater because groundwater has an excellent natural microbiological quality and generally adequate chemical quality for most uses (Pudentiana & Luke 2012). The use of geophysics for both groundwater resource mapping and for water quality evaluations has increased dramatically over the years. The Vertical Electrical Soundings (VES) has proved very popular with groundwater studies due to simplicity of the technique. Using this method, depth and thickness of various subsurface layers, the depth and thickness of aquifers, fissure or fracture location and their water yielding capabilities can be inferred (Sunmonu, 2012). The electrical geophysical survey method is the detection of the surface effects produced by the flow of electric current inside the earth. The electrical techniques have been adopted in this study.

The evaluation of groundwater potential at ABUAD international school was done in order to know the groundwater yielding capabilities and groundwater conditions of the study area. In basement complex, unweathered basement rocks contain negligible groundwater. Significant aquifers however, develop within the weathered overburden and fractured bedrock. (Oyegoke, 1986). This research is undertaken to know the feasibility of potable borehole water in the school (i.e. to know the promising areas for groundwater prospects within the study area). This was done in order to advise the management of the school and building engineers not to build on the available zones for groundwater exploration and to know the promising zones for groundwater exploration in the study area. Also, the groundwater conditions of the study area when properly understood could be used as an effective tool in the planning of a reliable water supply system.

The study area is underlain by Precambrian rocks of the Nigerian Basement Complex where aquifers are both isolated and compartmentalized. (Olorunfemi and Fasuyi, 1993; Olayinka *et al*, 1997). Considering the limited characteristics of the groundwater reservoirs in the Basement Complex, the full benefit of the aquifer system can only be exploited through a well coordinated hydro geophysical and geological investigation program of the prospective area.

In this paper, we examine the prospect of groundwater accumulation in the basement complex terrain of ABUAD International School, Ado Ekiti using a ranking procedure based on two geoelectric parameters, namely the Depth - to - Bedrock and the Bedrock Resistivity obtained from inversion of the resistivity sounding data.

# LOCATION AND GEOLOGY OF THE STUDY AREA

## Location

The present study involves delineation of depth of water table and groundwater potential at ABUAD International School, a newly established secondary school behind the ABUAD Children Amusement park, Ado-Ekiti. It is located between latitude 7°35'35"N to 7°36'15"N and longitude 5°18'01"E to 5°18'05"E, Ado-Ekiti, Southwestern Nigeria. Figure 1(a) and 1(b) show the Aerial photograph and Base map of the study location respectively.

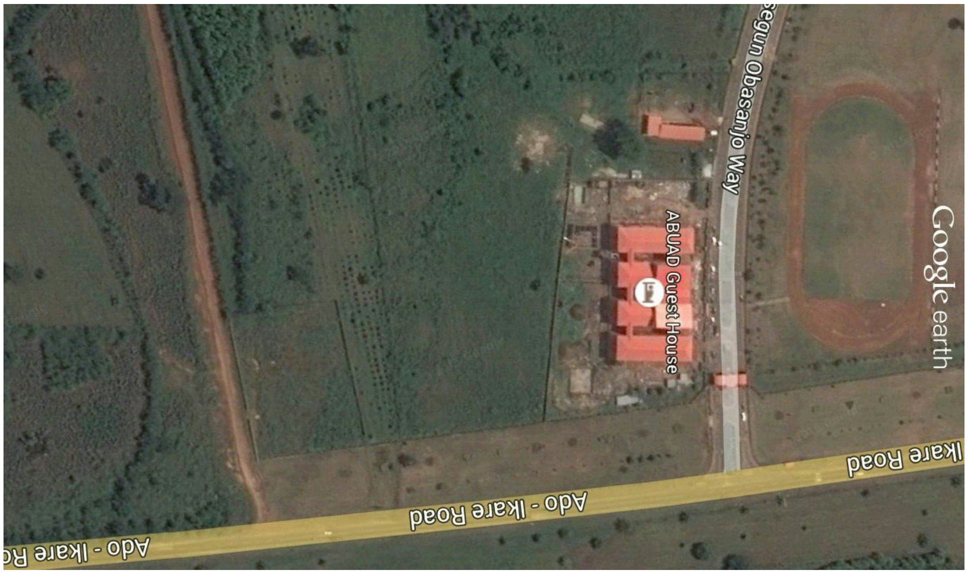


Figure 1(a): Aerial photograph of the Study Location

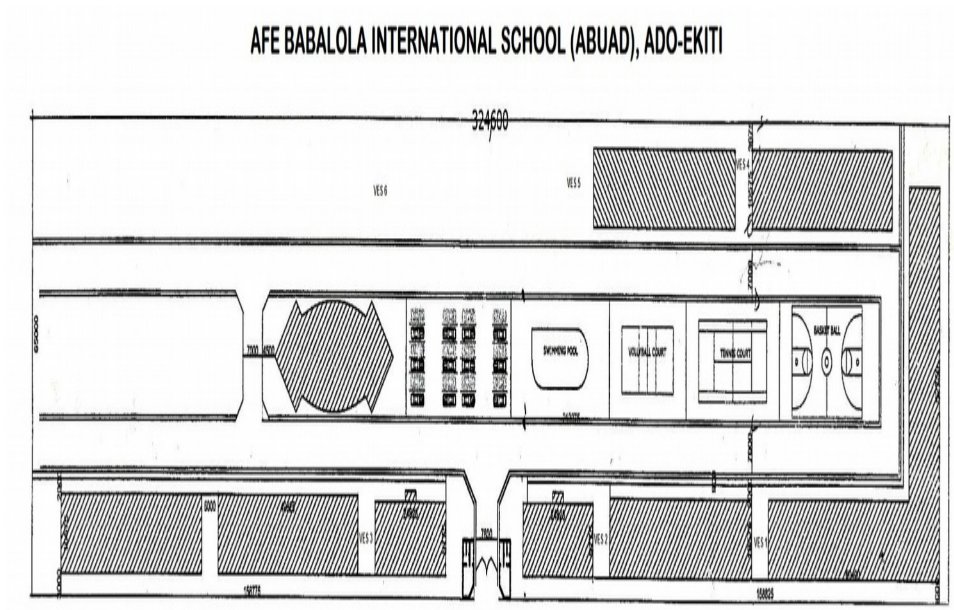


Figure 1(b): Base Map of the study area

**Geology**

The area is underlain by the Precambrian basement complex rocks of Southwestern Nigeria and is made up of older granite, Migmatite and Charnockites, it is drained by River Ogbese which flow into River Owena and empty into the Atlantic Ocean (Rahaman, 1988). The area is situated within the tropical rain forest region, with a climate characterized by dry and wet seasons. Average annual rainfall in this area is 1300 mm, with average wet days of about 100. The annual temperature varies between 18°C to 34°C. The groundwater is found within the overburden and fractured basement (Ogundana and Talabi, 2014)

Basement rocks are known to have very low porosity and negligible permeability. Consequently, the development of aquifer is limited to the overburden resulting from the insitu chemical weathering of the bedrock and the fissure/fracture system in the underlying bedrock. A pre-drilling geophysical investigation should therefore focus on how effectively those zones /fractures basement could be located.

## MATERIALS, METHODOLOGY AND DATA ANALYSIS

The geophysical survey was carried out using the electrical resistivity method. The Campus Ohmega R50 resistivity meter was used for resistance measurements. Good quality data were obtained with the observational errors being less than 1%.

To locate a productive site for the development of a productive borehole, six vertical electrical soundings were conducted within the study area. The electrodes were expanded from a minimum current electrode spacing (AB/2) of 1.0m to a maximum of 100m.

Field data were plotted on bilogarithmic coordinates and a preliminary interpretation was carried out using partial curve matching involving four-layer master curves and the appropriate auxiliary charts. Parameters such as apparent resistivity and thickness obtained from partial curve matching were used as input data for computer iterative modeling using the WinResist software (Vander Velpen, 2004). The VES curves generated gives the thickness and the resistivity of different sub surface layers.

## RESULTS AND DISCUSSIONS

Basement complex rocks are considered to be poor aquifers because of their low primary porosity and permeability necessary for groundwater accumulation (Davis and De-Weist , 1966). However, secondary porosity and permeability imposed on them by fracturing, fissuring, jointing, and weathering through which water percolates make them favorable for groundwater storage (Ngwisanyi, *et al* 1992). The sounding curve and it computer interpretation are presented on Figures 2-7. A total of 6 VES locations across 3 traverses were spread over the study area. The processed data were interpreted, resulting curve types were assessed, existing subsurface lithologic units were established and the geoelectric properties of the various subsurface layers were used in delineating the aquiferous units in the study area. The result of the sounding shows a system of four geo-electric layer respectively. The sequence comprises from top to bottom, the topsoil, sandy clay, weathered basement and partly fractured basement. Overburden ranges between 4.6 – 17.9m for the VES points. A summary of the VES interpretation is shown on Table 1 and summary of classification of the weathered layer resistivity is presented in Table 2. The basement resistivity indicates some degree of fracturing at the VES point and is expected to be saturated. For groundwater development in the study area the location around the VES 3, 5 & 6 can be drilled. Groundwater development in the study area would be enhanced if the partially fractured basement is fully penetrated. The borehole if drilled is expected to have good groundwater yield.

### Geoelectric Section

The geoelectric sections in Figure 8(a) and (b) show the variations of resistivity and thickness values of layers within the depth penetrated in the study area. The sections revealed four geo-electric layers. The first layer, for VESs 1, 3, 4, & 5 is characterized by top soil/hardpan lateritic clay with resistivity values from 269.7 Ohm.m to 916.9 Ohm.m and its thickness is between 1.8m to 2.6m. The second layer is suggestive of weathered granite with resistivity values from 20.9 Ohm.m to 52.2 Ohm.m and its thickness is between 4.6m to 16.3m and the third layer underneath is suggestive of slightly fractured

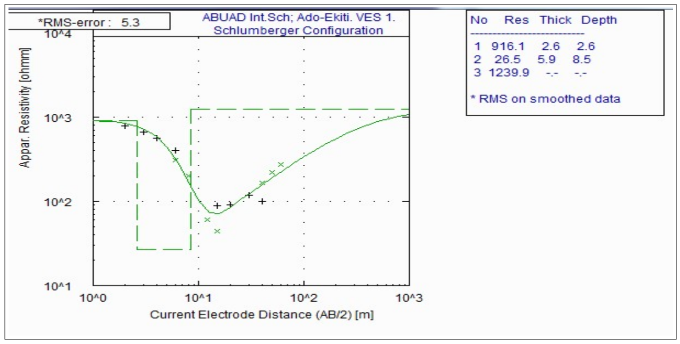


Figure 2: Modeled Curve for VES 1

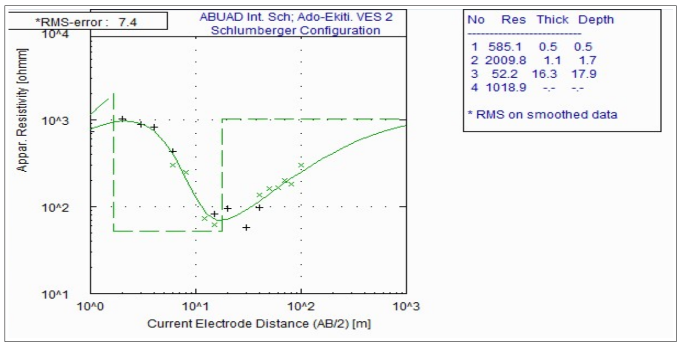


Figure 3: Modeled Curve for VES 2

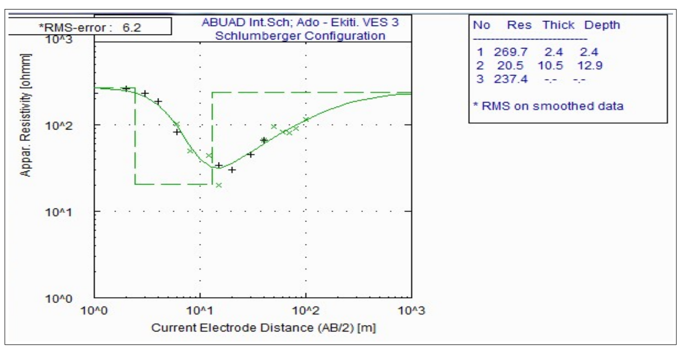


Figure 4: Modeled Curve for VES 3

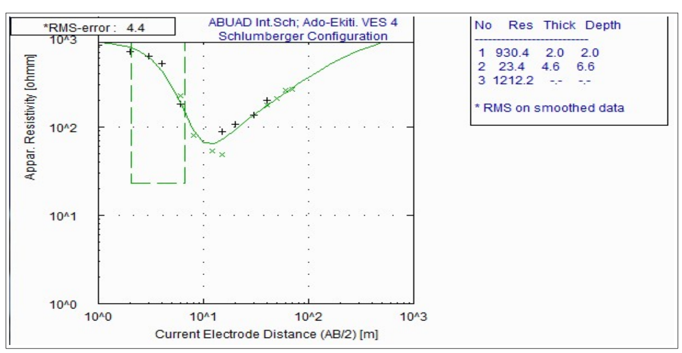


Figure 5: Modeled Curve for VES 4

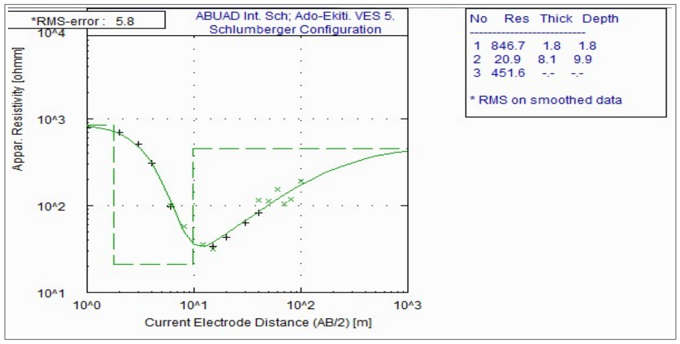


Figure 6: Modeled Curve for VES 5

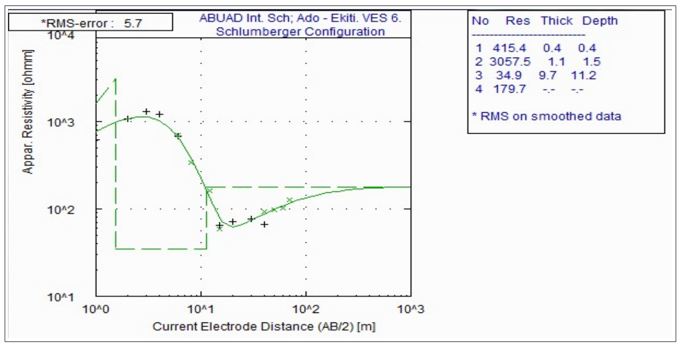


Figure 7: Modeled Curve for VES 6

Table 1. Summary of ABUAD International School VES Stations Data.

| VES POINT | | 1 | 2 | 3 | 4 | 5 | 6 | Layer hydrogeological Significance |
|---|---|---|---|---|---|---|---|---|
| CURVE TYPE | | H | K | H | HA | HK | K | |
| LITHOLOGY | | | | | | | | |
| TOP SOIL | TOP | 0 | 0 | 0 | 0 | 0 | 0 | Poor aquifer unit |
| | BOTTOM | 0.6 | 0.5 | 0.4 | 0.3 | 0.3 | 0.4 | |
| | THICKNESS | 0.6 | 0.5 | 0.4 | 0.3 | 0.3 | 0.4 | |
| | Ωm | 916.1 | 585.1 | 269.7 | 930.4 | 846.7 | 415.4 | |
| HARD PAN/LATERITIC CLAY | TOP | 0.6 | 0.5 | 0.4 | 0.3 | 0.3 | 0.4 | fair aquifer unit |
| | BOTTOM | 2.6 | 1.7 | 2.4 | 2.0 | 1.8 | 1.5 | |
| | THICKNESS | 2.0 | 1.1 | 2.0 | 1.7 | 1.5 | 1.1 | |
| | Ωm | 916.1 | 2009.8 | 269.7 | 930.4 | 846.7 | 3057.5 | |
| WEATHERED BASEMENT | TOP | 2.6 | 1.7 | 2.4 | 2 | 1.8 | 1.5 | Good aquifer unit |
| | BOTTOM | 8.5 | 17.9 | 12.9 | 6.6 | 9.9 | 11.2 | |
| | THICKNESS | 5.9 | 16.3 | 10.5 | 4.6 | 8.1 | 9.7 | |
| | Ωm | 26.5 | 52.2 | 52.2 | 23.4 | 20.9 | 34.9 | |
| FRACTURED BASEMENT | TOP | - | - | - | - | - | - | fair aquifer unit |
| | BOTTOM | - | - | - | - | - | - | |
| | THICKNESS | - | - | - | - | - | - | |
| | Ωm | 1239.9 | 1018.9 | 237.4 | 1212.2 | 451.6 | 179.7 | |

Table 2. Aquifer Potential as a Function of the Weathered Layer Resistivity (modified after Wright, 1992).

| Weathered Layer Resistivity (Ω m) | Range Aquifer characteristics | Weighting |
|---|---|---|
| <20 | Clay with limited potential | 7.5 |
| 21–100 | Optimum weathering and good groundwater potential | 10 |
| 101–150 | Medium conditions and potential | 7.5 |
| 151–300 | Little weathering and poor potential | 5 |
| >300 | Negligible potential | 2.5 |

Table 3. Aquifer Potential as a Function of the Depth to Bedrock

| Depth To Bedrock (m) | Weighting |
|---|---|
| <10 | 2.5 |
| 10-20 | 5.0 |
| 20-30 | 7.5 |
| >30 | 10.0 |

*Source:* Olayinka *et al*, 1997**.**

basement with resistivity values from 179.7 Ohm.m to 1239.9 Ohm.m and its thickness is between 4.6m to 16.3m. For VESs 2 & 6, the first layer is characterized by topsoil with resistivity values from 415.4 Ohm.m to 585.1 Ohm.m, its thickness is between 0.4m to 0.5m. The second layer is characterized by hardpan/lateritic clay with resistivity from 2009.8 Ohm.m to 3057.5 Ohm.m, it has an average thickness of 1.1m, the third layer is a suggestive of weathered basement with resistivity between 34.9 Ohm.m to 52.2Ohm.m with thickness ranging from 9.7m to 16.3m and the forth layer for consist of the slightly fractured basement with resistivity values from 179.7 Ohm.m to 1018.9 Ohm.m with unlimited thickness.

Generally, results obtain from the study area revealed four subsurface/geoelectric layers which are topsoil, hardpan/lateritic clay, weathered basement and fractured basement. Topsoil is relatively thin along these traverses. The average resistivity and thickness values for the topsoil are 500.25Ωm and 0.5m respectively. Hard pan/Lateritic clay was encountered at shallow depths of 2.0meters on the average and the average resistivity 2533 Ohm.m and average thickness values of 1.8m. Weathered-basement was encountered in six locations and the average resistivity and thickness values of 35.0Ωm and 9.2m respectively. Fractured-basement was also encountered with average resistivity of 723 Ohm.m with an unlimited depth.

**Overburden Thickness**

The depth to the basement (overburden thickness) beneath the sounding stations is assumed to include the topsoil, lateritic clay and weathered/fractured rock. The values range from 1.0m to 17.9m, with an average thickness value of 12.0m (Table 1 and Figure 8). Areas with thick overburden corresponding to basement depression are known to have high groundwater potential particularly in the basement complex area (Wright, 1992; Olorunfemi and Okhue, 1992; *Meju, et al*, 1993).

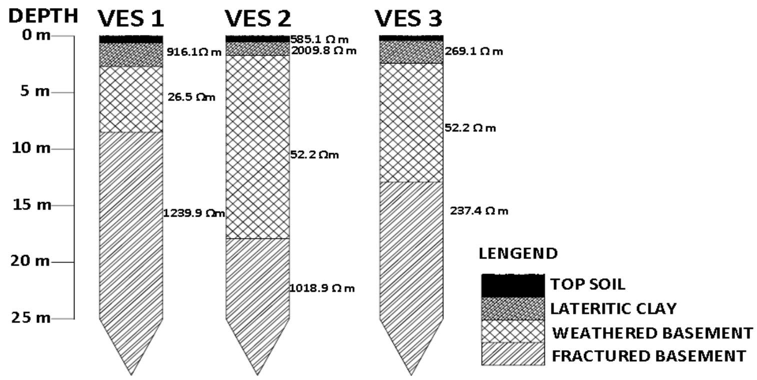


Figure 8(a): Geoelectric Sections of VES 1, 2 & 3 of Abuad International School, Ado-Ekiti.

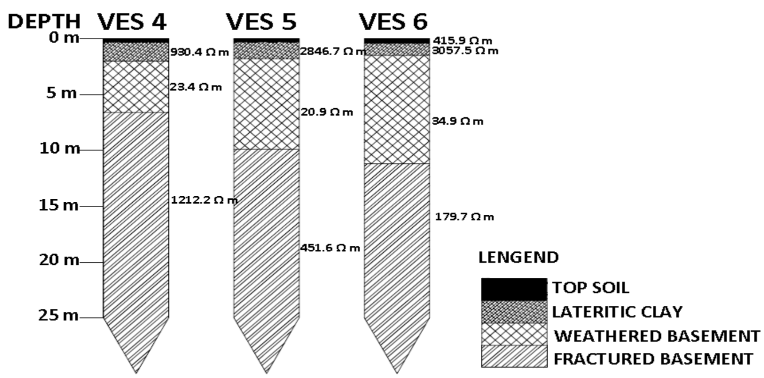


Figure 8(b): Geoelectric Sections of VES 4, 5 & 6 of Abuad International School, Ado-Ekiti.

**Groundwater potential**

VES 2, 3, 5 & 6 of the study area has thick overburden thickness while the VES 1 & 4 of the study area showed thin overburden thickness. For groundwater development in the study area the location around the VES 3, 5 & 6 can be drilled. Groundwater development in the study area would be enhanced if the partially fractured basement is fully penetrated. From the syntheses of the weathered layer resistivity and overburden thicknesses as well as the curve type and parametric data analyses, three (3) VESs positions have exhibited promising characteristics for possible groundwater development, these positions arranged in order of hydrogeologic significance are VES 3, 6 and 5, while other VESs positions including VESs 1, 2 and 4 exhibited low prospects. Two boreholes BH 1 and BH 2 located at VES positions 3 and 6 have therefore been proposed for the study area. The borehole if drilled is expected to have Good groundwater yield**.** Since the yield of a well in the Basement Complex is expected to have a positive correlation with the depth to bedrock. (Olayinka *et al*, 1997).

# CONCLUSION

Water still remains one of our essential amenities in life; the groundwater potential evaluation in the ABUAD international School, Ado-Ekiti cannot be overlooked. Ignorantly without carrying out geophysical survey, the building contractor might have decided to build on the promising areas for groundwater exploration which will lead to scarcity of groundwater in the study area.

It can be concluded that the low resistivity and significantly thick weathered rock/clay and the fractured basement constitute the aquifer in this area. Results from this study have revealed that The location around the VES **3, 5, & 6** points are the most promising region for borehole development and the estimated depth of the borehole is **60-65m** deep and the overburden btw **9.9 – 12.9m**. Airlift drilling technique can be adopted, Casing should be installed to the basement to avoid ingress of contaminants and the borehole must be gravel packed and well grouted to enhance water quality and promote borehole durability. The borehole if drilled at this VESs location is expected to have Good groundwater yield. VESs location 1 & 4 of the study area can also be considered as fair for borehole development.

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